REPLY

To: Takayuki UTAKA, Esq.

Examiner,

Patent Office

1. Designation of International Application:

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2. Applicant for Patent:

Name: HITACHI, LTD.

Address: 6-6, Marunouchi 1-chome, Chiyoda-ku, TOKYO 100-8280 JAPAN

Nationality: JAPAN

Domicile: JAPAN

3. Agent:

Name: OGAWA Katsuo, Patent Attorney (Reg. No. 6850)

Address: Nitto International Patent Office, 8th Floor, No. 17 Arai Building, 3-3, Shinkawa 1-chome, Chuo-ku, TOKYO 104-0033 JAPAN

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5. Details of Reply: As attached hereto.

1. The applicant has filed an Amendment as of the same date as the present Reply. Claims 1 to 4 have been amended in the present Amendment to make clear the invention of the present application. Further, claims 7 to 13 have been added to the Claims.

2. Reasons that the invention of the present application has patentability

(1) Description of the invention of the present application:

The amended claim 1 of the present application has a feature in that "the sequence control means performs, before the spectrum measurement sequence, control ..., and (6) to calculate, based on the calculated time-varying rate of the water magnetic resonant frequency, a received frequency at the time that the nuclear magnetic resonance signal is measured in the spectrum measurement sequence, and performs in the spectrum measurement sequence, control (7) to set the received frequency thus calculated".

The amended claim 2 has a feature in that "the sequence control means performs, before the spectrum measurement sequence, control ..., and (6) to calculate, using the estimated time-varying rate of the magnetic resonant frequency of water, a transmission frequency of the RF magnetic field and a received frequency at which the magnetic resonance signal generated from the voxel is received, in the spectrum measurement sequence,

and performs control to repeat, plural times, the spectrum measurement sequence that performs a measurement of the magnetic resonance signal generated from the voxel after the setting of the transmission frequency and the received frequency thus calculated".

The amended claim 3 has a feature in that "the sequence control means performs control, ..., and (3) to set, based on a time-varying rate of the magnetic resonant frequency of water detected in said (2), a transmission frequency of the RF magnetic field radiated into the target and a received frequency at the measurement of the magnetic resonance signal in the spectrum measurement sequence executed subsequently to the pre-scan".

The amended claim 4 has a feature in that "the sequence control means performs, ..., control ..., and (3) to set, based on a time-varying rate of the magnetic resonant frequency of water detected in said (2), a transmission frequency of the RF magnetic field radiated into the target and a received frequency at the measurement of the magnetic resonance signal in a pulse sequence executed subsequently to the pre-scan".

With the above features, the amended claims 1 to 4 of the present application bring about an advantageous effect that "a high-precision MRS measurement is enabled" (refer to the 5th and 6th lines in page 17 in the specification of the present application). A magnetic resonance imaging system can be provided which is capable of avoiding an increase in measurement

time even when a magnetic resonant frequency changes during measurement and carrying out a high-precision spectrum measurement (refer to the 14th to 16th lines in page 26 in the specification of the present application).

Claim 5 of the present application has a feature in that "the sequence control means performs control, ..., and (4) to, based on the magnetic resonant frequency of water detected in said (3), set a transmission frequency of the RF magnetic field irradiated in the water suppression sequence ...". With its feature, the corresponding claim brings about an operative effect that "the suppression of a water signal can sufficiently be conducted and a half-value width of the peak of NAA becomes also narrow, and the peaks of choline and creatine can also be separated and hence detection at high decomposition is enabled"(refer to the 7th to 13th lines in page 17 in the specification of the present application).

Further, claim 7 (independent claim) added this time has a feature in that "the sequence control means performs control, ..., (3) to monitor a signal strength of a water signal peak in a magnetic resonance spectrum obtained by Fourier-transforming a magnetic resonance signal obtained by the continuous execution of said (1) and (2), (4) to determine that a water magnetic resonant frequency has been shifted when the signal strength of the water signal peak is increased to a predetermined value or more, and (5) to execute a pre-scan

for measuring the water magnetic resonant frequency of water when the water magnetic resonant frequency is judged to have been shifted in said (4)". Thus, the corresponding claim brings about an operative effect that "a large increase in measurement time can be avoided" (refer to the 4th to 16th lines in page 23 in the specification of the present application).

The added claim 11 (independent claim) has a feature in that "the sequence control means, ..., and selects and excites a voxel different from the predetermined voxel and placed in the neighborhood thereof to measure a magnetic resonant frequency of water upon the pre-scan thereby to prevent the predetermined voxel from being excited". With its feature, the corresponding claim bring about advantageous effects that "when the pre-scan for detecting the water magnetic resonant frequency is performed using the MRS pulse sequence shown in Fig. 3, the voxel V2 different from the imaging voxel V1 intended for measurement upon MRS measurement may be set as a measurement voxel for the pre-scan done to detect the water magnetic resonant frequency (if V2 is selected in the neighborhood of the imaging voxel V1, then time-varying rates of magnetic resonant frequencies at both voxels become equal). If the excitation of the imaging voxel V1 to be measured upon MRS measurement is avoided during the pre-scan, then longitudinal relaxation of nuclear magnetization contained in the imaging voxel V1 proceeds without any delay even during the pre-scan. Therefore,

if the pre-scan is done in a spare time of a repetitive measurement time for MRS measurement, then the scan or measurement for continuously performing the pulse sequence (see Fig. 4) for suppressing the water signal and the MRS pulse sequence (see Fig. 3), and the pre-scan can be repeated without prolonging the total measurement time, thereby making it possible to avoid an increase in measurement time" (refer to the 6th to 18th lines in page 22 in the specification of the present application).

The added claim 12 (independent claim) has a feature in that "the sequence control means ..., and narrows an excitation bandwidth of the RF magnetic field upon execution of the pre-scan in such a manner that nuclear magnetization contained in water is excited and nuclear magnetization contained in metabolites is not excited". Thus, the corresponding claim brings about operative effects that "if the excitation of nuclear magnetization contained in metabolites is avoided during the pre-scan, then longitudinal relaxation of the nuclear magnetization contained in the metabolites proceeds without any delay even during the pre-scan. Therefore, if the pre-scan is done in a spare time of a repetitive measurement time for MRS measurement, then the scan or measurement for continuously performing the pulse sequence (see Fig. 4) for suppressing the water signal and the MRS pulse sequence (see Fig. 3), and the pre-scan can be repeated without prolonging the total measurement time, thereby making it possible to avoid an increase

in measurement time" (refer to the 26th line in page 20, and the 15th line in page 21 in the specification of the present application).

The added claim 13 has a feature in that "the sequence control means performs ..., and (4) to change, based on the magnetic resonant frequency of water detected in said (3), a transmission frequency of the RF magnetic field irradiated in the water suppression sequence, a transmission frequency of the RF magnetic field in the spectrum measurement sequence and a received frequency at the detection of the magnetic resonance signal". Thus, the corresponding claim 13 brings about an operative effect that "a high-precision spectrum measurement is enabled even when the magnetic resonant frequency changes during MRS or MRSI measurement" (refer to the 23rd and 24th lines in page 4 in the specification of the present application).

(2) Description of cited references:

A cited reference 1 has described a sequence of INS (Interleaved navigator scan)-MRS in which (1) a water suppression scheme, (2) application of a spoiler magnetic field (G), (3) selection of PRESS volume (α-β-β), (4) acquisition of a metabolite signal (FID), (5) application of a spoiler magnetic field (G), (6) excitation subsequent to TR_{NAV} from the start of (3) (γ-β-β) (a water suppression pulse is not shown), and (7) acquisition of a navigator signal (NAV) are repeated in TR_{EXP}, and has described that automatic phase corrections

of metabolic spectrums with respect to distortion due to a magnetic field drift, an eddy current and a magnetic susceptibility effect are executed by deconvolution related to navigation data about individual metabolic data (see Fig. 1 and "MATERIALAS AND METHODS"). Further, the quality of INS PRESS spectra does not depend on a drift of a main magnetic field, and no reduction in signal strength or spectrum resolution occurs" (page 1079).

A cited reference 2 includes a description of "the measurement of a magnetic resonant frequency fd corresponding to a dth time by a magnetic resonant frequency measuring pulse sequence" (paragraph [0039]), a description of "the amount of variation in dth-time magnetic resonant frequency Δfd is determined using, for example, (1) a difference fd − f0 in frequency between the magnetic resonant frequency fd and a reference magnetic resonant frequency f0 and (2) a difference fd − f_{d-1} in frequency between the magnetic resonant frequency fd and a previously-measured f_{d-1}" (paragraph [0042], a description of "when the absolute value |Δfd| of Δfd is smaller than a threshold value R, a frequency variation correction is executed, and the frequency variation correction can be carried out based on the amount of variation in magnetic resonant frequency Δfd, using, for example, either processing for (b) adjusting a transmission frequency of an RF oscillator circuit or processing for (c) adjusting a transmission frequency and

a received frequency of the RF oscillator circuit" (paragraphs [0043] and [0044]), a description of "since a frequency variation correction is effected on a frequency drift slow in time-varying rate to enable adaptation to a subsequent frequency variation, and a phase correction computation is effected on a frequency drift fast in time-varying rate subsequently, imaging data prior to the start of the frequency drift can also be corrected" (paragraph [0052]), a description of "a magnetic resonant frequency measuring pulse sequence is inserted once each time an imaging pulse sequence is carried out twice" (paragraph [0055]), a description of "since the amount of variation in magnetic resonant frequency Δfd is measured only once each time the imaging pulse sequences is carried out twice, the total scan time can be shortened"(paragraph [0056]), a description of "a predicted value Δfd' of the amount of variation in magnetic resonant frequency Δfd is calculated by the conventional known prediction method" (paragraph [0059]), and a description of "adaptation to all of a frequency drift slow in time-varying rate, a frequency drift in a slice direction and a frequency drift fast in time-varying rate is enabled and the quality of an image can be improved" (paragraph [0071]).

A cited reference 3 includes a description of "a point that exerts the most important influence is stability of a static magnetic field. ..., and a magnetic field strength changes with an ambient temperature, and it cannot be used in chemical

imaging" (the 12th line on the upper right-hand section in page 2 to the 17th line on the same section), a description of "NMR signal from a sample is measured without applying a gradient magnetic field and a center frequency f_0 in a spectrum obtained by Fourier-transforming the NMR signal is measured, whereby magnetic field strengths at times t_1 and t_2 can be determined" (the 12th on the upper left-hand section in page 3 to the 11th line on the upper right-hand section in the same page), a description of "if the magnetic field strengths at least the two times are measured, then future magnetic field strengths can be predicted. A method for correcting a phase error at chemical shift imaging or a frequency error of an RF magnetic field for selective excitation using the thus-determined magnetic field strengths will now be described" (the 12th line on the upper right-hand section in page 3 to the 7th line on the same section), a description of "since an RF magnetic field (e.g., f_1) for selective excitation, which applies an RF magnetic field modulated so as to include a specific frequency component and excites only a spin having a specific magnetic resonant frequency, is proportional to a static magnetic field, f_1 also varies with a variation in the static magnetic field and hence there is a need to measure f_1 prior to the measurement. If the magnetic field strength can be predicted, then efforts to measure f_1 every measurements can be omitted" (the 17th line on the lower right-hand section in page 3 to the 14th line on the upper

left-hand section in page 4), and a description of "since the frequency error of the RF magnetic field for selective excitation is corrected, there is an effect in obtaining a chemical shift image with a high degree of accuracy" (the 4th to 7th lines on the lower right-hand section in page 4).

(3) Comparison between the invention of the present application and the cited references:

The cited reference 1 includes the description of "the water suppression scheme (WS)", the cited reference 2 includes the descriptions of "the magnetic resonant frequency measuring pulse sequence which measures the magnetic resonant frequency fd" and "the transmission frequency of the RF oscillator circuit or the transmission frequency and received frequency of the RF oscillator circuit are adjusted on the basis of the amount of variation in the magnetic resonant frequency Δfd determined as the difference in frequency between the magnetic resonant frequency fd and the reference magnetic resonant frequency f0 or the difference in frequency between the magnetic resonant frequency fd and the previously-measured f_{d-1}", and the cited reference 3 includes the description of "the relationship between the center frequency of the spectrum and the static magnetic field strength (8)", the description of "an equation which expresses a monotonous attenuation change in magnetic field strength of a super conductive magnet", and the description of "if the magnetic filed strengths can be predicted, then the

efforts to measure f_1 every measurements can be omitted and the value for correction of the RF magnetic field for selective excitation can be determined from the equations (7) and (8)".

In the cited reference 1, however, the phase correction of each metabolic spectrum with respect to the distortion due to the magnetic field drift is performed by processing executed after the completion of measurement of the nuclear magnetic resonance signal. In the cited reference 2, the transmission frequency of the RF oscillator circuit or the transmission frequency and received frequency of the RF oscillator circuit are adjusted based on the amount of variation in the magnetic resonant frequency Δfd determined as the difference between the magnetic resonant frequency fd measured this time and the previously-measured f_{d-1}. In the cited reference 3, the correction value of the RF magnetic field for selective excitation is determined.

Accordingly, any cited reference makes no mention of "the time-varying rate of the magnetic resonant frequency of water is determined and the received frequency at the measurement of the nuclear magnetic resonance signal is calculated and set using it in the spectrum measurement sequence", "the transmission frequency of the RF magnetic field irradiated in the water suppression sequence is set based on the magnetic resonant frequency of water", "the signal strength of the water signal peak is monitored", "when the signal strength of the

water signal peak is increased to the predetermined value or more, the water magnetic resonant frequency is judged to have been shifted", "In order to measure the magnetic resonant frequency of water upon the pre-scan, the voxel different from the predetermined voxel and placed in the neighborhood of the predetermined voxel is selected and excited in such a manner that the predetermined voxel is not excited", and "Upon execution of the pre-scan, the excitation bandwidth of the RF magnetic field is narrowed in such a manner that the nuclear magnetization contained in water is excited and the nuclear magnetization contained in each metabolite is not excited".

That is, any cited reference makes no description of the characteristic particulars of the invention of the present application referred to above and does not show any suggestion either.

3. Conclusion:

Accordingly, the invention of the present application according to claims 1 to 4, 5 and 7 to 13 referred to above does not describe its constitution and operative effects in any of the cited references 1 to 3 and brings about novel and remarkable operative effects unexpectable from such cited references. The present invention is therefore not believed to be such that could be easily created by those skilled in the art on the basis of the references. Incidentally, the claims 8 to 10 are claims dependent on claim 7 corresponding to an

independent claim. Similarly, they are believed to be patentable.

Reexamination is respectfully requested with the understanding of the spirit of the invention of the present application referred to above.

Respectfully submitted,